US012071864B2

(12) United States Patent
Liles et al.

(10) Patent No.: US 12,071,864 B2
(45) Date of Patent: Aug. 27, 2024

(54) **TURBINE SECTION WITH CERAMIC SUPPORT RINGS AND CERAMIC VANE ARC SEGMENTS**

(71) Applicant: **RAYTHEON TECHNOLOGIES CORPORATION**, Farmington, CT (US)

(72) Inventors: **Howard J. Liles**, Newington, CT (US); **Bryan P. Dube**, Columbia, CT (US)

(73) Assignee: **RTX CORPORATION**, Farmington, CT (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 128 days.

(21) Appl. No.: **17/581,170**

(22) Filed: **Jan. 21, 2022**

(65) **Prior Publication Data**

US 2023/0235675 A1 Jul. 27, 2023

(51) **Int. Cl.**
F01D 9/04 (2006.01)
F01D 5/28 (2006.01)

(52) **U.S. Cl.**
CPC ***F01D 9/041*** (2013.01); ***F01D 5/284*** (2013.01); ***F01D 9/042*** (2013.01); *F05D 2240/12* (2013.01); *F05D 2240/80* (2013.01); *F05D 2250/291* (2013.01); *F05D 2260/30* (2013.01); *F05D 2300/6033* (2013.01)

(58) **Field of Classification Search**
CPC F01D 9/041; F01D 5/284; F01D 9/042; F05D 2240/12; F05D 2240/80; F05D 2250/291; F05D 2260/30; F05D 2300/6033
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,857,649 A 12/1974 Schaller et al.
4,076,451 A 2/1978 Jankot
(Continued)

FOREIGN PATENT DOCUMENTS

EP 1104836 6/2001
EP 1669547 6/2006
(Continued)

OTHER PUBLICATIONS

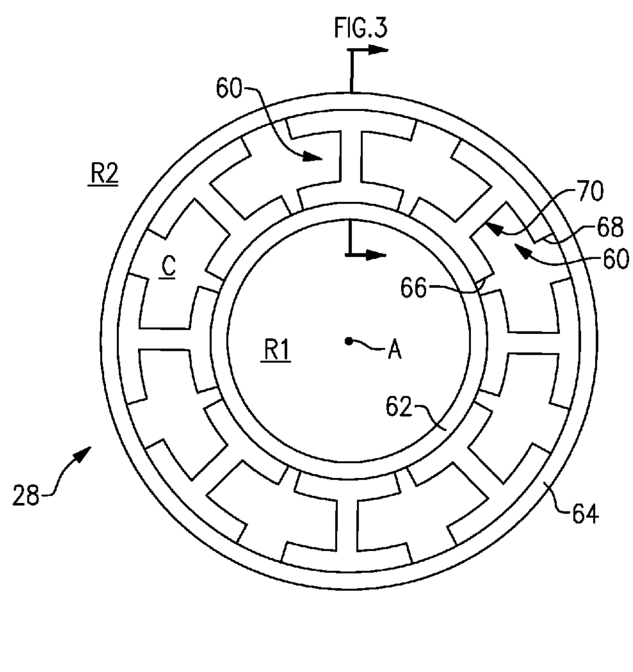
European Search Report for European Patent Application No. 22207350.4 dated Jan. 30, 2023.
(Continued)

Primary Examiner — Jacob M Amick
Assistant Examiner — Charles J Brauch
(74) *Attorney, Agent, or Firm* — Carlson, Gaskey & Olds, P.C.

(57) **ABSTRACT**

A gas turbine engine includes a turbine section disposed about an engine axis. The turbine section includes inner and outer diameter ceramic support rings that define a gaspath there between. Each of the inner and outer diameter ceramic support rings is monolithic and continuous. Ceramic vane arc segments are disposed in the gaspath and supported by the inner and outer diameter ceramic support rings. Each of the ceramic vane arc segments includes inner and outer platforms and an airfoil section there between. At least one retainer engages the inner or outer diameter ceramic support ring with the ceramic vane arc segments to retain the ceramic vane arc segments between the inner and outer diameter ceramic support rings.

14 Claims, 6 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

5,026,595	A	6/1991	Crawford et al.	
5,941,446	A	8/1999	Yasui et al.	
6,398,485	B1	6/2002	Frosini et al.	
7,445,426	B1	11/2008	Matheny et al.	
8,905,711	B2	12/2014	Suciu et al.	
10,392,951	B2	8/2019	Carr et al.	
10,975,706	B2	4/2021	Farrar et al.	
2003/0002979	A1	1/2003	Koschier	
2003/0059577	A1	3/2003	Morrison et al.	
2006/0130994	A1*	6/2006	Grunstra	B22C 9/103 164/369
2008/0019836	A1	1/2008	Butz et al.	
2008/0279679	A1	11/2008	Morrison	
2010/0196155	A1	8/2010	Twell	
2010/0284805	A1	11/2010	Uskert et al.	
2013/0052030	A1	2/2013	McCaffrey	
2013/0136605	A1	5/2013	Bart et al.	
2013/0149159	A1	6/2013	Chuong et al.	
2016/0201488	A1	7/2016	Carr et al.	
2019/0360348	A1*	11/2019	Carr	F01D 5/3084
2021/0102469	A1	4/2021	Sobanski et al.	
2021/0164352	A1	6/2021	Backhouse et al.	
2021/0246808	A1	8/2021	Sobanski et al.	
2021/0317786	A1	10/2021	Sobanski	

FOREIGN PATENT DOCUMENTS

EP	2549121	1/2013
EP	2570602	3/2013
EP	2998510	3/2016
EP	3339573	6/2018
EP	3650653	5/2020
GB	2525985	11/2015

OTHER PUBLICATIONS

European Search Report for European Patent Application No. 23152741.7 dated May 19, 2023.

* cited by examiner

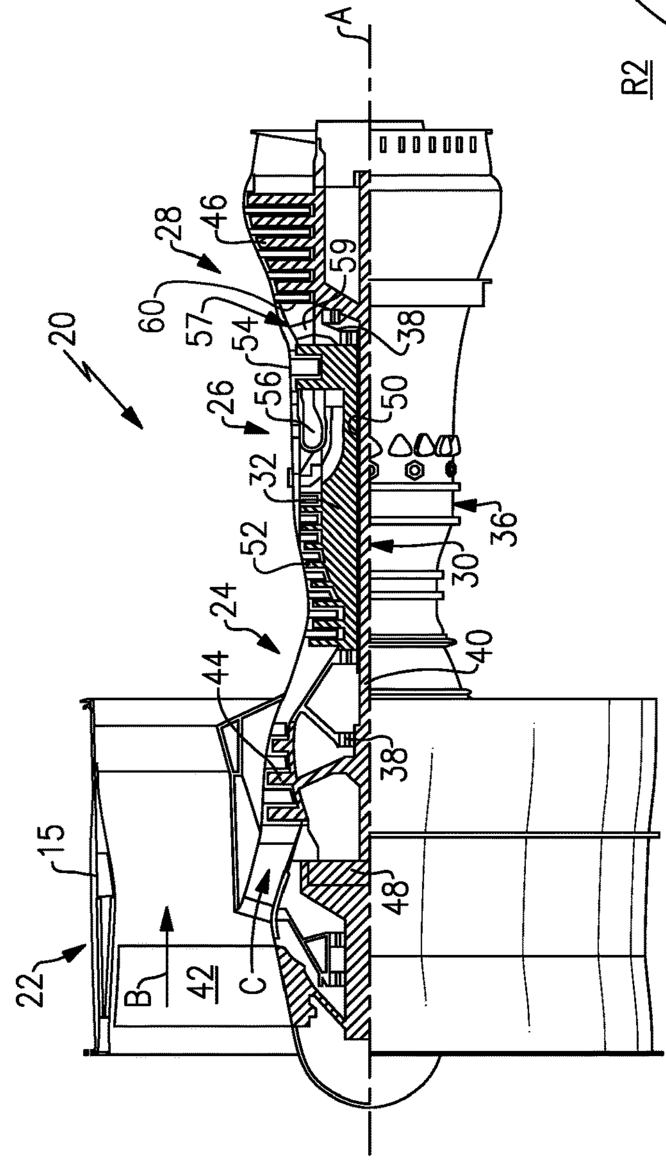

20
22
15
B
42
C
44
48
38
24
40
52
30
32
36
26
56
50
54
57
60
59
38
28
46
A

FIG.1

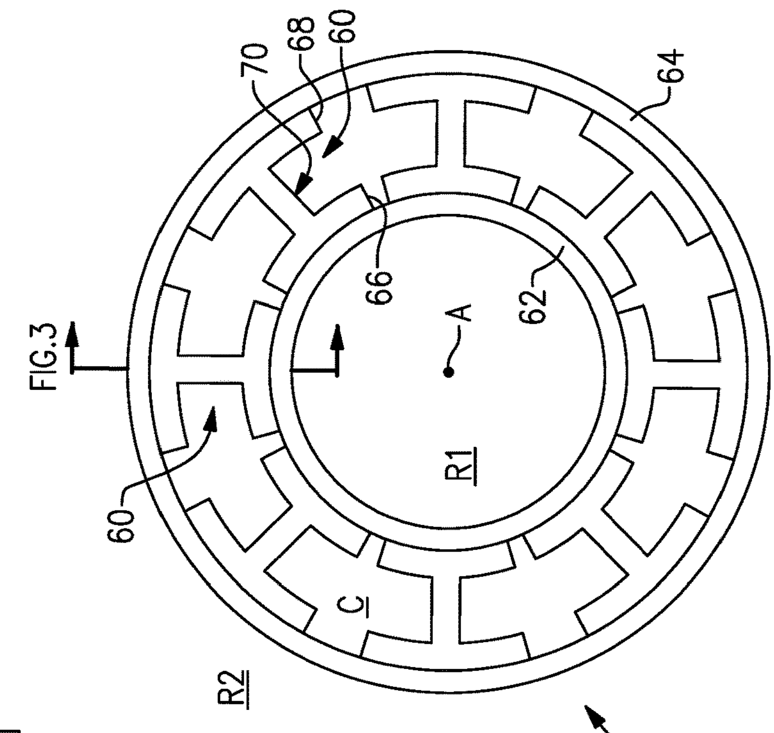

70
68
60
64
66
62
A
FIG.3
R1
60
C
R2
28

FIG.2

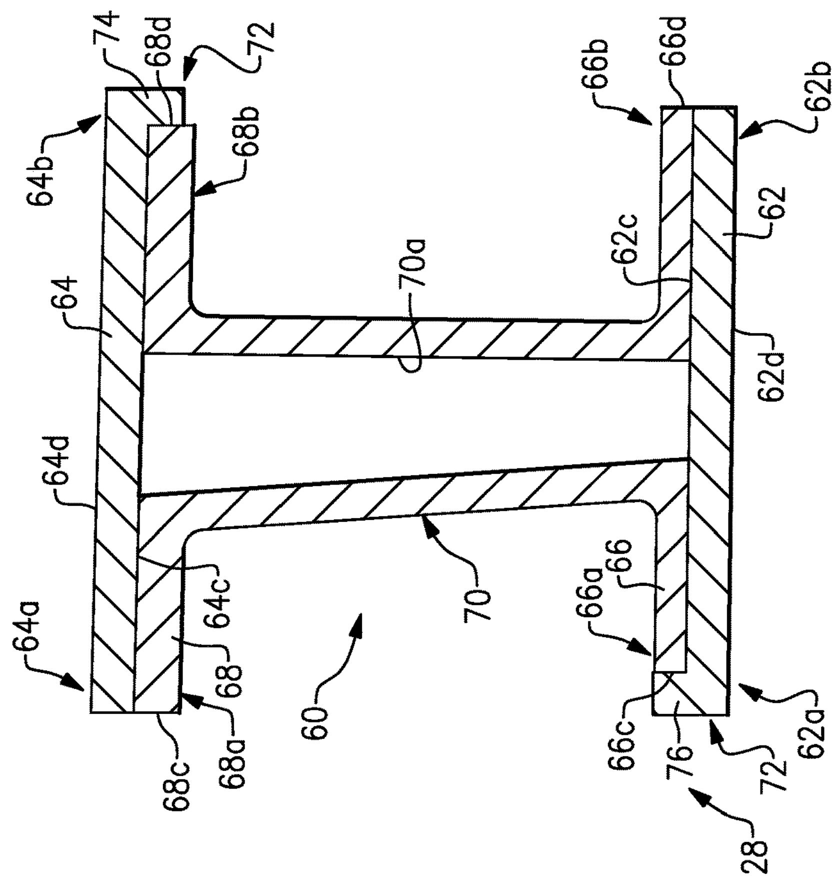

28
60
62
62a
62b
62c
62d
64
64a
64b
64c
64d
66
66a
66b
66c
66d
68
68a
68b
68c
68d
70
70a
72
74
76

FIG.3

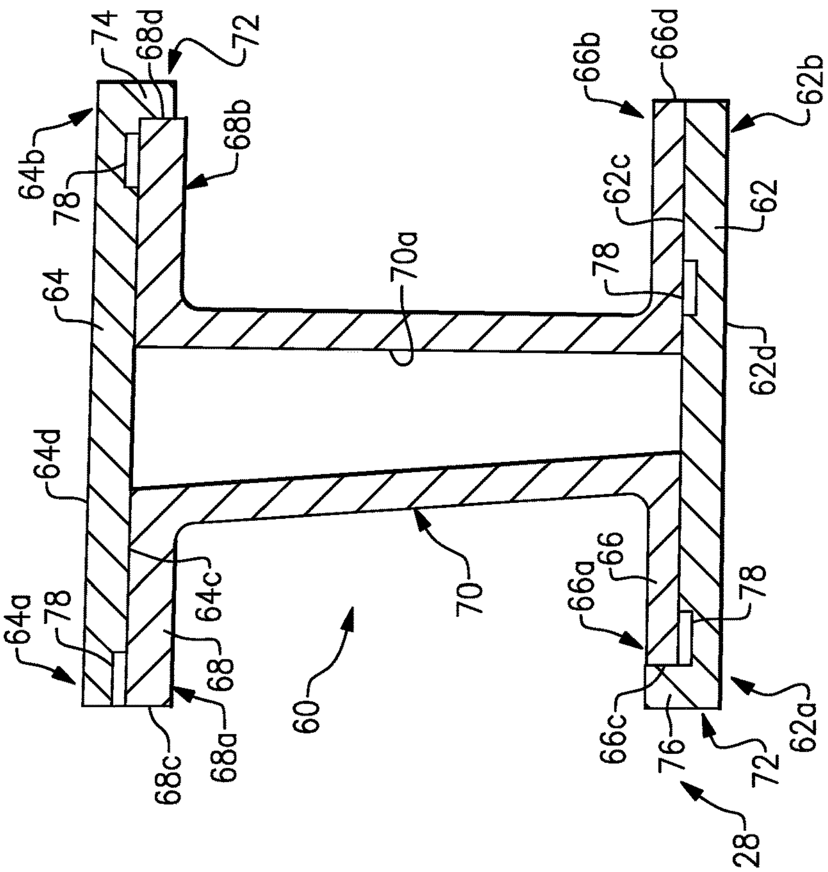

28
60
62
62a
62b
62c
62d
64
64a
64b
64c
64d
66
66a
66b
66c
66d
68
68a
68b
68c
68d
70
70a
72
74
76
78

FIG.4A

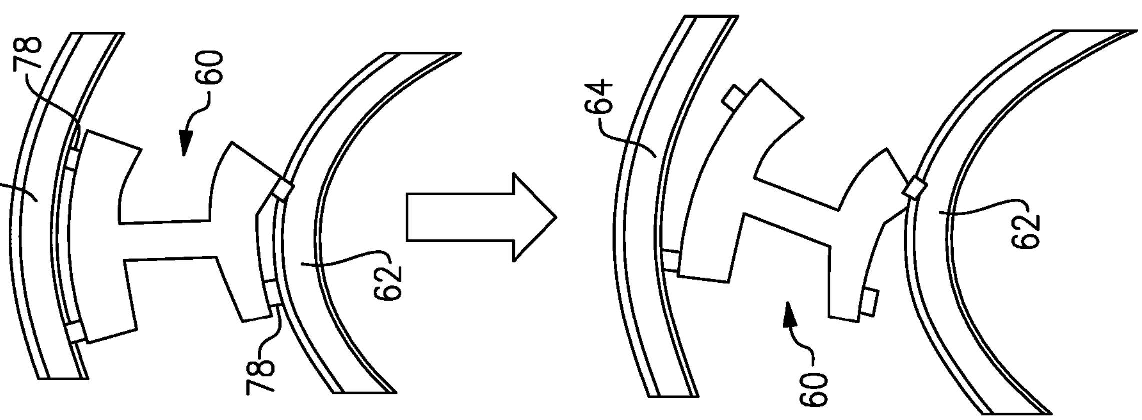


FIG.4B

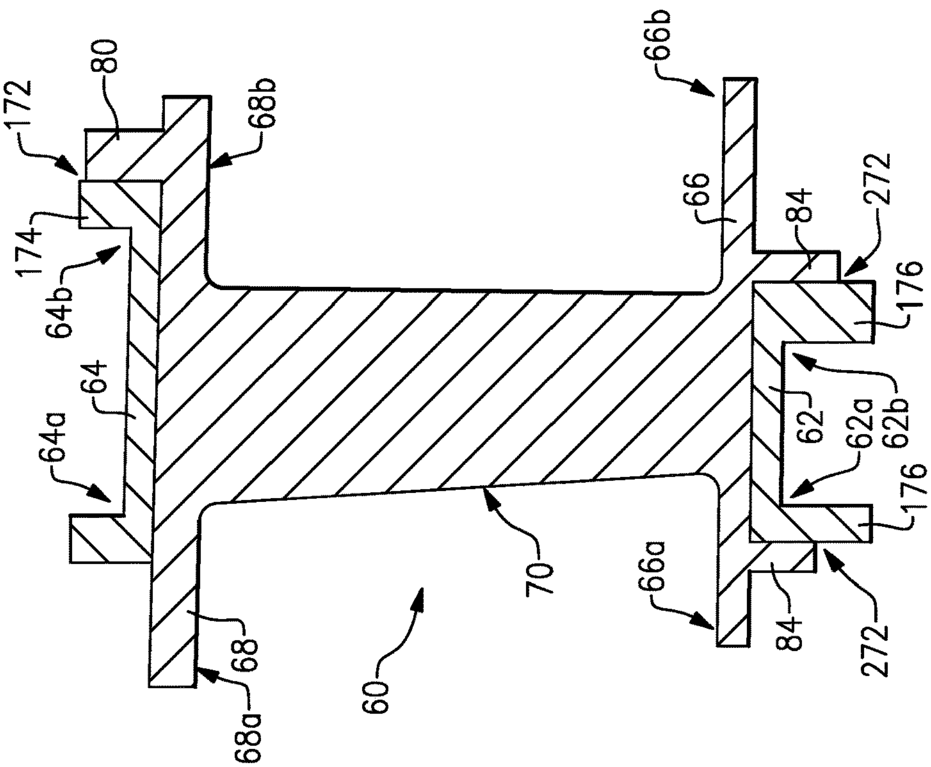

172
80
68b
66b
174
64b
64
64a
66
84
272
176
62
62a
62b
70
60
68
68a
66a
84
272

FIG.6

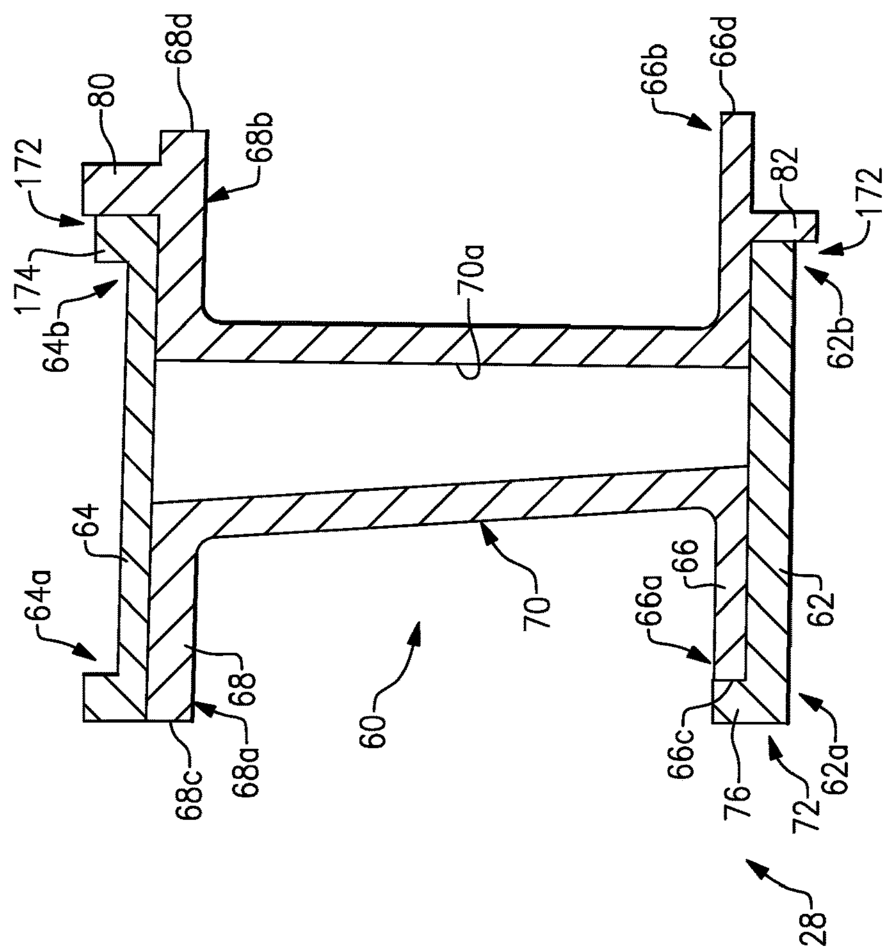

172
80
68d
68b
174
64b
64
64a
70a
66b
66d
82
172
62b
70
60
68
68a
68c
66a
66
66c
76
72
62
62a
28

FIG.5

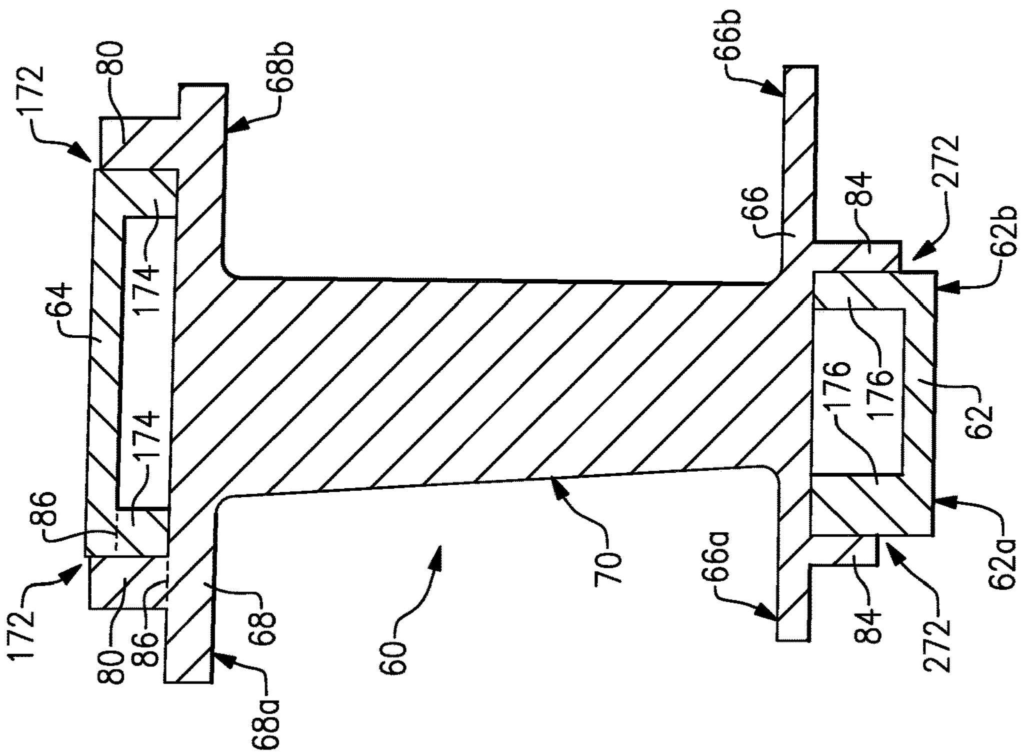

60
62
62a
62b
64
66
66a
66b
68
68a
68b
70
80
84
86
172
174
176
272

FIG.8

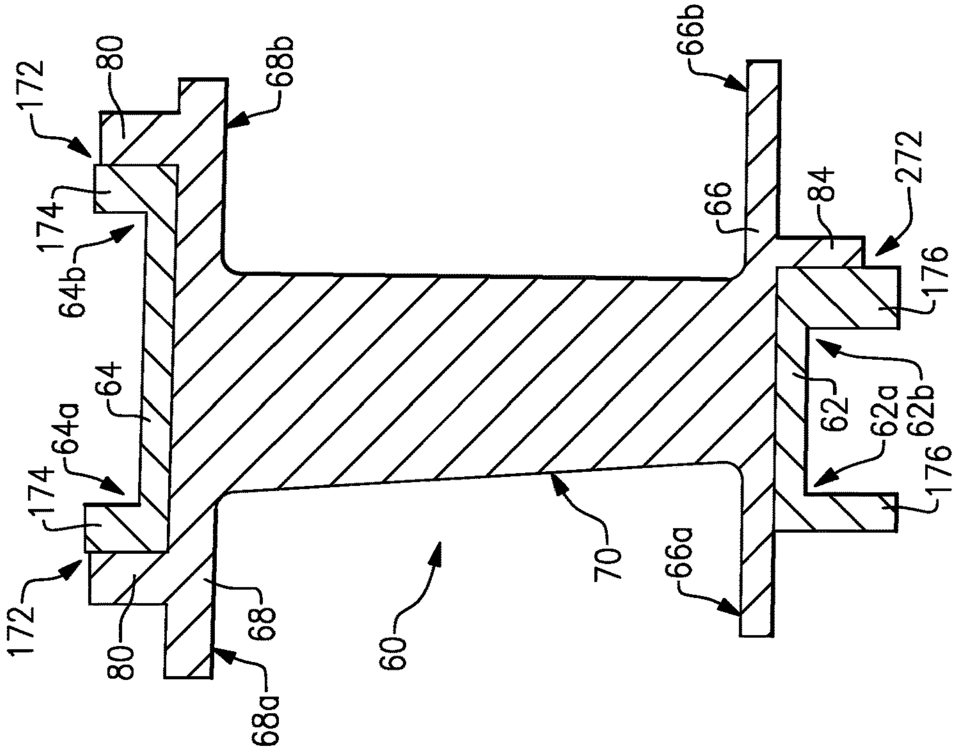

60
62
62a
62b
64
64a
64b
66
66a
66b
68
68a
68b
70
80
84
172
174
176
272

FIG.7

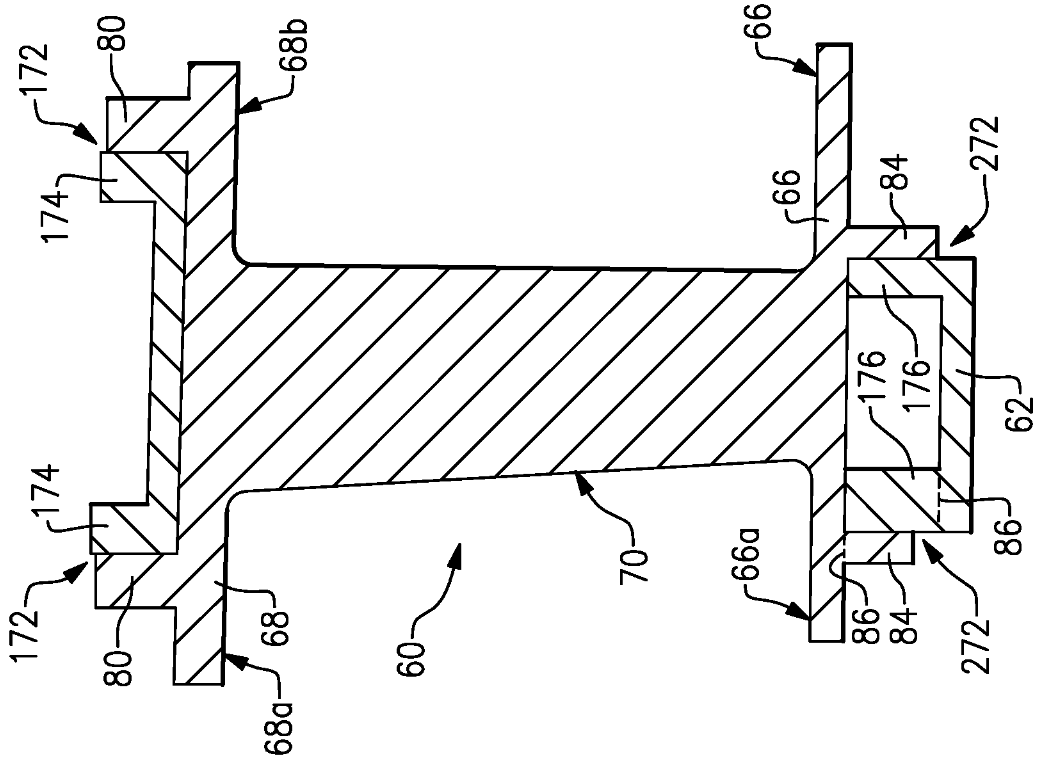

172
80
68b
66b
174
66
84
272
176
176
62
174
86
70
60
66a
172
80
68
68a
86
84
272

FIG.9

TURBINE SECTION WITH CERAMIC SUPPORT RINGS AND CERAMIC VANE ARC SEGMENTS

BACKGROUND

A gas turbine engine typically includes a fan section, a compressor section, a combustor section and a turbine section. Air entering the compressor section is compressed and delivered into the combustion section where it is mixed with fuel and ignited to generate a high-pressure and temperature exhaust gas flow. The high-pressure and temperature exhaust gas flow expands through the turbine section to drive the compressor and the fan section. The compressor section may include low and high pressure compressors, and the turbine section may also include low and high pressure turbines.

Airfoils in the turbine section are typically formed of a superalloy and may include thermal barrier coatings to extend temperature capability and lifetime. Ceramic materials are also being considered for airfoils. Among other attractive properties, ceramics have high temperature resistance. Despite this attribute, however, there are unique challenges to implementing ceramic in airfoils.

SUMMARY

A gas turbine engine according to an example of the present disclosure includes a turbine section disposed about an engine axis. The turbine section includes inner and outer diameter ceramic support rings that define a gaspath there between. Each of the inner and outer diameter ceramic support rings are monolithic and continuous. Ceramic vane arc segments are disposed in the gaspath and supported by the inner and outer diameter ceramic support rings. Each of the ceramic vane arc segments includes inner and outer platforms and an airfoil section there between, and at least one retainer engages the inner or outer diameter ceramic support ring with the ceramic vane arc segments to retain the ceramic vane arc segments between the inner and outer diameter ceramic support rings.

In a further embodiment of any of the foregoing embodiments, the outer diameter ceramic support ring defines an outer diameter support ring aft end and a first support ring flange that extends radially-inwardly from the outer diameter support ring aft end. The first support ring flange servs as the at least one retainer and engaging an aft face of the outer platform.

In a further embodiment of any of the foregoing embodiments, the inner diameter ceramic support ring defines an inner diameter support ring forward end and a second support ring flange that extends radially-outwardly from the inner diameter support ring forward end. The second support ring flange additionally servs as the at least one retainer and engaging a forward face of the inner platform.

In a further embodiment of any of the foregoing embodiments, there is at least one contact pad between each of i) the outer diameter ceramic support ring and the outer platform and ii) the inner diameter ceramic support ring and the inner platform.

In a further embodiment of any of the foregoing embodiments, the outer diameter ceramic support ring defines an outer diameter support ring aft end and a first support ring flange that extends radially-outwardly from the outer diameter support ring aft end, and the outer platform defines an outer platform aft end and a first platform flange that extends radially-outwardly from the outer platform aft end. An aft face of the first support ring flange serves as the at least one retainer and engaging a forward face of the first platform flange.

In a further embodiment of any of the foregoing embodiments, the inner platform defines an inner platform aft end and a second platform flange that extends radially inwardly from the inner platform aft end. The inner diameter ceramic support ring includes an inner diameter support ring aft face serving as the at least one retainer and engages a forward face of the second platform flange.

In a further embodiment of any of the foregoing embodiments, the inner diameter ceramic support ring circumscribes a radially inner region, and the inner diameter ceramic support ring fluidly isolates the gaspath from the inner region.

In a further embodiment of any of the foregoing embodiments, the outer diameter ceramic support ring bounds a radially outer region and fluidly isolates the gaspath from the radially outer region.

In a further embodiment of any of the foregoing embodiments, the inner and outer diameter ceramic support rings and the ceramic vane arc segments are ceramic matrix composite.

In a further embodiment of any of the foregoing embodiments, the airfoil section of each of the ceramic vane arc segments is hollow.

A further embodiment of any of the foregoing embodiments includes a compressor section, a combustor in fluid communication with the compressor section and the turbine section.

A turbine section for a gas turbine engine according to an example of the present disclosure includes inner and outer diameter ceramic matrix composite (CMC) support rings that define a gaspath there between. Each of the inner and outer diameter CMC support rings are monolithic and continuous. CMC vane arc segments are disposed in the gaspath and supported by the inner and outer diameter CMC support rings. Each of the CMC vane arc segments includes inner and outer platforms and an airfoil section there between. At least one retainer engages the inner or outer diameter CMC support rings with the CMC vane arc segments to retain the CMC vane arc segments between the inner and outer diameter CMC support rings.

In a further embodiment of any of the foregoing embodiments, the outer diameter CMC support ring defines an outer diameter support ring aft end and a first support ring flange that extends radially-inwardly from the outer diameter support ring aft end, the first support ring flange serves as the at least one retainer and engaging an aft face of the outer platform.

In a further embodiment of any of the foregoing embodiments, the inner diameter CMC support ring defines an inner diameter support ring forward end and a second support ring flange that extends radially-outwardly from the inner diameter support ring forward end. The second support ring flange additionally serves as the at least one retainer and engaging a forward face of the inner platform.

In a further embodiment of any of the foregoing embodiments, there is at least one contact pad between each of i) the outer diameter CMC support ring and the outer platform and ii) the inner diameter CMC support ring and the inner platform.

In a further embodiment of any of the foregoing embodiments, the outer diameter CMC support ring defines an outer diameter support ring aft end and a first support ring flange that extends radially-outwardly from the outer diameter support ring aft end, and the outer platform defines an outer platform aft end and a first platform flange that extends radially-outwardly from the outer platform aft end. An aft face of the first support ring flange serves as the at least one retainer and engaging a forward face of the first platform flange.

In a further embodiment of any of the foregoing embodiments, the inner platform defines an inner platform aft end and a second platform flange that extends radially inwardly from the inner platform aft end. The inner diameter ceramic support ring includes an inner diameter support ring aft face serving as the at least one retainer and engaging a forward face of the second platform flange.

In a further embodiment of any of the foregoing embodiments, the inner diameter CMC support ring circumscribes a radially inner region, and the inner diameter CMC support ring fluidly isolates the gaspath from the inner region.

In a further embodiment of any of the foregoing embodiments, the outer diameter CMC support ring bounds a radially outer region and fluidly isolates the gaspath from the radially outer region.

In a further embodiment of any of the foregoing embodiments, the airfoil section of each of the CMC vane arc segments is hollow.

The present disclosure may include any one or more of the individual features disclosed above and/or below alone or in any combination thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

The various features and advantages of the present disclosure will become apparent to those skilled in the art from the following detailed description. The drawings that accompany the detailed description can be briefly described as follows.

FIG. **1** illustrates a gas turbine engine.

FIG. **2** illustrates a portion of the turbine section of the gas turbine engine.

FIG. **3** illustrates a sectioned view of a portion of the turbine section.

FIG. **4**A illustrates another example in which there are contact pads between the platforms and the support rings.

FIG. **4**B illustrates a thermal mismatch between inner and outer support rings.

FIG. **5** illustrates another example, in which the platforms also have flanges to retain the vane arc segment.

FIG. **6** illustrates an example of another configuration of retainers in which there are two retainers at the inner diameter.

FIG. **7** illustrates an example of another configuration of retainers in which there are two retainers at the outer diameter.

FIG. **8** illustrates an example of another configuration of retainers in which there are two retainers at the inner and outer diameter and the flanges at the outer diameter are castellated.

FIG. **9** illustrates an example of another configuration of retainers in which there are two retainers at the inner and outer diameter and the flanges at the inner diameter are castellated.

DETAILED DESCRIPTION

FIG. **1** schematically illustrates a gas turbine engine **20**. The gas turbine engine **20** is disclosed herein as a two-spool turbofan that generally incorporates a fan section **22**, a compressor section **24**, a combustor section **26** and a turbine section **28**. The fan section **22** drives air along a bypass flow path B in a bypass duct defined within a housing **15** such as a fan case or nacelle, and also drives air along a core flow path C for compression and communication into the combustor section **26** then expansion through the turbine section **28**. Although depicted as a two-spool turbofan gas turbine engine in the disclosed non-limiting embodiment, it should be understood that the concepts described herein are not limited to use with two-spool turbofans as the teachings may be applied to other types of turbine engines including three-spool architectures.

The exemplary engine **20** generally includes a low speed spool **30** and a high speed spool **32** mounted for rotation about an engine central longitudinal axis A relative to an engine static structure **36** via several bearing systems **38**. It should be understood that various bearing systems **38** at various locations may alternatively or additionally be provided, and the location of bearing systems **38** may be varied as appropriate to the application.

The low speed spool **30** generally includes an inner shaft **40** that interconnects, a first (or low) pressure compressor **44** and a first (or low) pressure turbine **46**. The inner shaft **40** is connected to the fan **42** through a speed change mechanism, which in exemplary gas turbine engine **20** is illustrated as a geared architecture **48** to drive a fan **42** at a lower speed than the low speed spool **30**. The high speed spool **32** includes an outer shaft **50** that interconnects a second (or high) pressure compressor **52** and a second (or high) pressure turbine **54**. A combustor **56** is arranged in the exemplary gas turbine **20** between the high pressure compressor **52** and the high pressure turbine **54**. A mid-turbine frame **57** of the engine static structure **36** may be arranged generally between the high pressure turbine **54** and the low pressure turbine **46**. The mid-turbine frame **57** further supports bearing systems **38** in the turbine section **28**. The inner shaft **40** and the outer shaft **50** are concentric and rotate via bearing systems **38** about the engine central longitudinal axis A which is collinear with their longitudinal axes.

The core airflow is compressed by the low pressure compressor **44** then the high pressure compressor **52**, mixed and burned with fuel in the combustor **56**, then expanded through the high pressure turbine **54** and low pressure turbine **46**. The mid-turbine frame **57** includes airfoils **59** which are in the core airflow path C. The turbines **46**, **54** rotationally drive the respective low speed spool **30** and high speed spool **32** in response to the expansion. It will be appreciated that each of the positions of the fan section **22**, compressor section **24**, combustor section **26**, turbine section **28**, and fan drive gear system **48** may be varied. For example, gear system **48** may be located aft of the low pressure compressor, or aft of the combustor section **26** or even aft of turbine section **28**, and fan **42** may be positioned forward or aft of the location of gear system **48**.

The engine **20** in one example is a high-bypass geared aircraft engine. In a further example, the engine **20** bypass ratio is greater than about six (6), with an example embodiment being greater than about ten (10), and can be less than or equal to about 18.0, or more narrowly can be less than or equal to 16.0. The geared architecture **48** is an epicyclic gear train, such as a planetary gear system or other gear system, with a gear reduction ratio of greater than about 2.3. The gear reduction ratio may be less than or equal to 4.0. The low pressure turbine **46** has a pressure ratio that is greater than about five. The low pressure turbine pressure ratio can be less than or equal to 13.0, or more narrowly less than or equal to 12.0. In one disclosed embodiment, the engine **20** bypass ratio is greater than about ten (10:1), the fan diameter is significantly larger than that of the low pressure compressor **44**, and the low pressure turbine **46** has a pressure ratio that is greater than about five 5:1. Low pressure turbine **46** pressure ratio is pressure measured prior to an inlet of low pressure turbine **46** as related to the pressure at the outlet of the low pressure turbine **46** prior to an exhaust nozzle. The geared architecture **48** may be an epicycle gear train, such as a planetary gear system or other gear system, with a gear reduction ratio of greater than about 2.3:1 and less than about 5:1. It should be understood, however, that the above parameters are only exemplary of one embodiment of a geared architecture engine and that the present invention is applicable to other gas turbine engines including direct drive turbofans.

A significant amount of thrust is provided by the bypass flow B due to the high bypass ratio. The fan section **22** of the engine **20** is designed for a particular flight condition—typically cruise at about 0.8 Mach and about 35,000 feet (10,668 meters). The flight condition of 0.8 Mach and 35,000 ft (10,668 meters), with the engine at its best fuel consumption—also known as "bucket cruise Thrust Specific Fuel Consumption ('TSFC')"—is the industry standard parameter of lbm of fuel being burned divided by lbf of thrust the engine produces at that minimum point. The engine parameters described above and those in this paragraph are measured at this condition unless otherwise specified. "Low fan pressure ratio" is the pressure ratio across the fan blade alone, without a Fan Exit Guide Vane ("FEGV") system. The low fan pressure ratio as disclosed herein according to one non-limiting embodiment is less than about 1.45, or more narrowly greater than or equal to 1.25. "Low corrected fan tip speed" is the actual fan tip speed in ft/sec divided by an industry standard temperature correction of $[(\text{Tram } °\text{R})/(518.7 °\text{R})]^{0.5}$. The "Low corrected fan tip speed" as disclosed herein according to one non-limiting embodiment is less than about 1150.0 ft/second (350.5 meters/second), and can be greater than or equal to 1000.0 ft/second (304.8 meters/second).

FIG. **2** illustrates an example of a portion of the turbine section **28** of the engine **20**. The turbine section **28** includes ceramic vane arc segments **60** radially disposed between first and second (inner and outer) diameter ceramic support rings **62**/**64**. The support rings **62**/**64** define a portion of the core flow path C (gaspath) there between and support the ceramic vane arc segments **60**. Terms such as "inner" and "outer" refer to location with respect to the central engine axis A, i.e., radially inner or radially outer. Moreover, the terminology "first" and "second" as used herein is to differentiate that there are two architecturally distinct components or features. It is to be further understood that the terms "first" and "second" are interchangeable in the embodiments herein in that a first component or feature could alternatively be termed as the second component or feature, and vice versa.

The vane arc segments **60** and the support rings **62**/**64** are formed of ceramic, such as a monolithic ceramic, ceramic matrix composite (CMC), or combinations of CMCs and monolithic ceramics. CMCs are comprised of a ceramic reinforcement, which is usually ceramic fibers, in a ceramic matrix. Example ceramic matrices of the CMC are silicon-containing ceramic, such as but not limited to, a silicon carbide (SiC) matrix or a silicon nitride (Si_3N_4) matrix. Example ceramic reinforcement of the CMC are silicon-containing ceramic fibers, such as but not limited to, silicon carbide (SiC) fiber or silicon nitride (Si_3N_4) fibers. The ceramic matrix composite may be, but is not limited to, a SiC/SiC ceramic matrix composite in which SiC fiber tows are disposed within a SiC matrix. The fiber tows are arranged in a fiber architecture, which refers to an ordered arrangement of the tows relative to one another, such as a 2D woven ply or a 3D structure. Example monolithic ceramics may include, but are not limited to, SiC and Si_3N_4. Monolithic ceramics may include, but are not limited to, silicon carbide (SiC) or silicon nitride (Si_3N_4).

In general, support schemes for mounting structural vane arc segments formed of ceramic are challenging due to lower material stress limits in comparison to high strength superalloys used for some traditional vane segments. For instance, traditional support schemes that utilize hooks or a series of rails can concentrate stresses, create aerodynamic loads, and/or create thermal stresses which may exceed material limits of fiber-reinforced composites. Therefore, even though ceramic may have many potential benefits, such benefits cannot be realized without a suitable support scheme. In this regard, as discussed below, the disclosed attachment scheme facilitates low-stress support of the vane arc segments **60** while also reducing leakage of the core flow path C.

FIG. **3** illustrates a sectioned view through a portion of the turbine section **28**. Each of the vane arc segments **60** includes inner and outer platforms **66**/**68** and at least one airfoil section **70** there between. The inner platform **66** defines forward and aft ends **66***a*/**66***b*, and the outer platform **68** likewise defines forward and aft ends **68***a*/**68***b*. The forward ends **66***a*/**68***a* have respective forward faces **66***c*/**68***c*, and the aft ends **66***b*/**68***b* have respective aft faces **66***d*/**68***d*. In general, as used herein, "forward" and "aft" ends are the portions in the axially forward 20% or axially aft 20% of the component (by axial length).

The airfoil section **70** in this example is hollow and defines an internal cavity **70***a*. The cavity **70***a* serves to reduce the mass of the vane arc segment **60**. Although cavities in general are sometimes used for cooling, the cavity **70***a* here does not receive cooling air, as the vane arc segments **60** are uncooled. In one variation, the cavity **70***a* receives cooling air to pass to a downstream component for cooling. In this case, sealing may be required to reduce leakage of the cooling air. Alternatively, the airfoil section **70** may be solid as shown in some of the example embodiments herein. In the illustrated example, the vane arc segments **60** are configured as "singlets" in which each separate segment **60** has only a single airfoil section **70**. It is to be understood, however, that this disclosure also contemplates use of "multiplets" in which each segment **60** has more than one airfoil section **70**, such as two or three airfoil sections **70**.

Each of the support rings **62**/**64** is monolithic and continuous. The term "monolithic" means that the support rings **62**/**64** are each unitary bodies that do not have mechanical joints. The inner support ring **62** defines a support ring forward end **62***a*, a support ring aft end **62***b*, and inner and outer sides **62***c*/**62***d*. Likewise, the outer support ring **64** defines a support ring forward end **64***a*, a support ring aft end **64***b*, and inner and outer sides **64***c*/**64***d*. The term "continuous" indicates that the rings are uninterrupted full hoops that do not have mate faces that require sealing, but does not preclude holes for cooling air or small borescope holes for inspection. As a result, the rings **62**/**64** do not have mate faces and seals that may result in leakage losses.

The turbine section **28** further includes at least one retainer **72** engaging the inner or outer diameter ceramic support ring **62**/**64** with the vane arc segments **60** to retain the segments **60** there between. In the example illustrated in FIG. **3**, the support ring **64** includes a first support ring flange **74** that extends radially-inwardly from the support ring aft end **64***b*. The first support ring flange **74** serves as the retainer **72** and engages the aft face **68***d* of the outer platform **68**. The first support ring flange **74** limits axially aft movement of the vane arc segment **60**. Additionally in the illustrated example, the support ring **62** includes a second support ring flange **76** that extends radially-outwardly from the support ring forward end **62***a*. The second support ring flange **76** serves as another retainer **72** and engages the forward face **66***c* of the inner platform **66**. The second support ring flange **76** limits axially aft movement of the vane arc segment **60**.

The support rings **62**/**64** with the flanges **74**/**76** enable the mechanical support of the vane arc segments **60** without the need for internal spars to support the load. The support rings **62**/**64** also serve to react aerodynamic loads from the vane arc segments **60** to an outer turbine case. Additionally, the use of ceramic in the support rings **62**/**64** reduces mass in comparison to denser nickel alloys and enables avoidance of the need for dedicated cooling due to interfacing with the hot vane arc segments **60** or the close proximity to the gaspath. The full hoop, continuous nature of the support rings **62**/**64** also eliminates leakage via intersegment gaps between the vane arc segments **60** since there are no mate faces for gases to pass through the support rings **62**/**64**. For example, the inner support ring **62** circumscribes a radially inner region **R1** and fluidly isolates the core flow path C from the inner region R**1**. Similarly, the outer support ring **64** fluidly isolates the core flow path C from a radially outer region R**2**. Such fluid isolation facilitates minimizing leakages and enhancing engine performance. Additionally, making the vane arc segments **60** and the support rings **62**/**64** from ceramics that have similar thermal coefficients of thermal expansion facilitates better thermal growth match to reduce any radial gap or mismatch between the vane arc segments **60** and the support rings **62**/**64** due to thermal growth or thermal transients during engine operation.

FIG. **4**A illustrates a further example that is the same as the example of FIG. **3** except that there is at least one contact pad **78**. In the example shown, there are four contact pads **78**, with two contact pads **78** between the support ring **64** and the platform **68** and two contact pads **78** between the support ring **62** and the platform **66**. The contact pads **78** may be in locations at which loads are transferred between the support rings **62**/**64** and the platforms **66**/**68**. For example, the contact pads **78** may be flanges that are integrally formed with the platforms **66**/**68** or components that are formed separately and then attached to the platforms **66**/**68** and/or support rings **62**/**64**. The contact pads **78** may also serve to maintain contact between the platforms **66**/**68** and the support rings **62**/**64** when there is thermal expansion/contraction between the platforms **66**/**68** and the support rings **62**/**64**. For instance, the top illustration in FIG. **4**B shows the vane arc segment **60** in a baseline condition in which each of the contact pads **78** is in contact with the respective rings **62**/**64**. The bottom illustration in FIG. **4**B shows the vane arc segment **60** under a thermal mismatch condition between the rings **62**/**64**, which has caused the vane arc segment **60** to rotate. In this condition, two of the contact pads **78** have lifted from contact with the rings **62**/**64**. However, the opposed contact pads **78** keep in contact with the rings **62**/**64** and thus permit the vane arc segment **60** to tolerate some thermal mismatch between the rings **62**/**64** while still maintaining contact to transmit loads.

FIG. **5** illustrates a similar example except that the support ring **64** includes a first support ring flange **174** that extends radially-outwardly from the support ring aft end **64***b*. The platform **68** also includes a first platform flange **80** that extends radially-outwardly from the platform aft end **68***b*. The aft face of the first support ring flange **174** serves as a retainer **172** and engaging a forward face of the first platform flange **80**. The first support ring flange **174** limits axially forward movement of the vane arc segment **60**. As shown, the platform **66** also has a second platform flange **82** that extends radially inwardly from the platform aft end **66***b*. The aft face of the support ring **62** serves as another retainer **172** and engages the forward face of the second platform flange **82**. The aft face of the support ring **62** limits axially forward movement of the vane arc segment **60**.

FIG. **6** illustrates a similar example in which the support ring **64** includes a first support ring flange **174** that extends radially-outwardly from the support ring aft end **64***b* and the platform **68** also includes a first platform flange **80** that extends radially-outwardly from the platform aft end **68***b*. The aft face of the first support ring flange **174** serves as a retainer **172** and engaging a forward face of the first platform flange **80**. The first support ring flange **174** limits axially forward movement of the vane arc segment **60**. As shown, the platform **66** also has second platform flanges **84** that, respectively, extend radially inwardly from the platform forward and aft ends **66***a*/**66***b*. The second support ring **62** includes second support ring flanges **176** that, respectively, extend radially inwardly from the support ring forward and aft ends **62***a*/**62***b*. The aft face of the second support ring flange **176** at the support ring aft end **62***b* serves as another retainer **272** and engages the forward face of the second platform flange **84** on the platform aft end **66***b* to limit axially aft movement of the vane arc segment **60**. The forward face of the second support ring flange **176** at the support ring forward end **62***a* serves as another retainer **272** and engages the aft face of the second platform flange **84** on the platform forward end **66***a* to limit axially forward movement of the vane arc segment **60**. Thus, there are two retainers **272** on the inner diameter of the vane arc segment.

FIG. **7** is similar to FIG. **6** except that instead of having two retainers **272**, the vane arc segment **60** has two retainers **172** on the outer diameter of the vane arc segment and the inner diameter has only a single retainer **272**. The single retainer (**172** in FIG. **6** and **272** in FIG. **7** permits that vane arc segment **60** to be assembled with the support rings **62**/**64** from one axial side.

FIGS. **8** and **9** illustrate examples in which both the inner and outer diameters of the vane arc segment **60** have a pair of retainers **172** and a pair of retainers **272**. In FIG. **8**, the forward ones of the flanges **80** and **174** are castellated with notches **86**. The vane arc segment **60** and the support ring **64** can be circumferentially clocked with respect to each other such that the notches misalign and thereby permit the flange **80** to pass axially through the flange **174** during assembly. Once the flange **80** passes and clears the flange **174**, the vane arc segment **60** is rotated so that it is unable to pass back though the flange **174**. FIG. **9** is similar except that it is the inner ring **62** and flanges **84** and **176** that have the notches **86**.

Although a combination of features is shown in the illustrated examples, not all of them need to be combined to realize the benefits of various embodiments of this disclosure. In other words, a system designed according to an embodiment of this disclosure will not necessarily include all of the features shown in any one of the Figures or all of the portions schematically shown in the Figures. Moreover, selected features of one example embodiment may be combined with selected features of other example embodiments.

The preceding description is exemplary rather than limiting in nature. Variations and modifications to the disclosed examples may become apparent to those skilled in the art that do not necessarily depart from this disclosure. The scope of legal protection given to this disclosure can only be determined by studying the following claims.

What is claimed is:

1. A gas turbine engine comprising:

a turbine section disposed about an engine axis, the turbine section including

inner and outer diameter ceramic support rings that define a gaspath there between, each of the inner and outer diameter ceramic support rings being monolithic and continuous,

ceramic vane arc segments disposed in the gaspath and supported by the inner and outer diameter ceramic support rings, each of the ceramic vane arc segments including inner and outer platforms and an airfoil section there between, and

at least one retainer engaging the inner or outer diameter ceramic support ring with the ceramic vane arc segments to retain the ceramic vane arc segments between the inner and outer diameter ceramic support rings, at least one of the inner or outer diameter ceramic support ring defining a first support ring flange extending radially therefrom, the first support ring flange serving as the at least one retainer and engaging the inner or outer platforms of the vane arc segments, and the first support ring flange being castellated with notches, permitting the vane arc segments to be passed axially through the first support ring flange and then rotated to so that the vane arc segments, once rotated, are then unable to pass back through the first support ring flange.

2. The gas turbine engine as recited in claim **1**, wherein the outer diameter ceramic support ring defines an outer diameter support ring aft end and a first support ring flange that extends radially-inwardly from the outer diameter support ring aft end, the first support ring flange serving as the at least one retainer and engaging an aft face of the outer platform.

3. The gas turbine engine as recited in claim **2**, wherein the inner diameter ceramic support ring defines an inner diameter support ring forward end and a second support ring flange that extends radially-outwardly from the inner diameter support ring forward end, the second support ring flange additionally serving as the at least one retainer and engaging a forward face of the inner platform.

4. The gas turbine engine as recited in claim **3**, wherein there is at least one contact pad between each of i) the outer diameter ceramic support ring and the outer platform and ii) the inner diameter ceramic support ring and the inner platform.

5. The gas turbine engine as recited in claim **1**, wherein the outer diameter ceramic support ring defines an outer diameter support ring aft end and a first support ring flange that extends radially-outwardly from the outer diameter support ring aft end, and the outer platform defines an outer platform aft end and a first platform flange that extends radially-outwardly from the outer platform aft end, an aft face of the first support ring flange serving as the at least one retainer and engaging a forward face of the first platform flange.

6. The gas turbine engine as recited in claim **5**, wherein the inner platform defines an inner platform aft end and a second platform flange that extends radially inwardly from the inner platform aft end, the inner diameter ceramic support ring including an inner diameter support ring aft face serving as the at least one retainer and engaging a forward face of the second platform flange.

7. The gas turbine engine as recited in claim **1**, wherein the inner diameter ceramic support ring circumscribes a radially inner region, and the inner diameter ceramic support ring fluidly isolates the gaspath from the inner region.

8. The gas turbine engine as recited in claim **7**, wherein the outer diameter ceramic support ring bounds a radially outer region and fluidly isolates the gaspath from the radially outer region.

9. The gas turbine engine as recited in claim **1**, wherein the inner and outer diameter ceramic support rings and the ceramic vane arc segments are ceramic matrix composite.

10. The gas turbine engine as recited in claim **1**, wherein the airfoil section of each of the ceramic vane arc segments is hollow.

11. The gas turbine engine as recited in claim **1**, further comprising a compressor section, a combustor in fluid communication with the compressor section and the turbine section.

12. The gas turbine engine as recited in claim **1**, wherein the outer diameter ceramic support ring defines an outer diameter support ring aft end and a first support ring flange that extends radially-inwardly from the outer diameter support ring aft end, and the outer platform defines an outer platform aft end and a first platform flange that extends radially-outwardly from the outer platform aft end, an aft face of the first support ring flange serving as the at least one retainer and engaging a forward face of the first platform flange.

13. The gas turbine engine as recited in claim **12**, wherein the first support ring flange extends radially-inwardly from the outer diameter support ring aft end at an axially aft 20% of the outer diameter ceramic support ring.

14. The gas turbine engine as recited in claim **1**, wherein the inner and outer diameter ceramic support rings and the ceramic vane arc segments include a silicon-containing ceramic.

* * * * *